Motility of the Gastric Tube after Surgery of the Upper Alimentary Tract with Special Reference to High Pressure Zone at the Gastroduodenal Junction

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Motility of the Gastric Tube after Surgery of the Upper Alimentary Tract with Special Reference to High Pressure Zone at the Gastroduodenal Junction

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Introduction

After resection of thoracic esophageal cancer and the creation of the KIRSCHNER-NAKAYAMA type of gastric tube, the motor and secretory functions of the gastric tube for esophageal reconstruction are disturbed owing to bilateral truncal vagotomy, usually accompanied with those operative procedures. In the Second Surgical Clinic of our University Hospital, RAMSTEDT pyloromyotomy or HEINEKE-MIKULICZ pyloroplasty is performed additionally on the gastric tube for antethoracic reconstruction or intrathoracic reconstruction, respectively.

Then, in order to clarify the motility of the gastric tube, the author investigated the effects of various kinds of pyloroplasties, vagotomy, splanchnicotomy and the creation of various sizes of gastric tubes on the high pressure zone (HPZ) at the gastroduodenal junction, and studied the alteration in the electrical activity of the gastric tubes in dogs. On the other hand, the author clinically measured the pressure value at the gastroduodenal junction and gastric emptying time using ^{99m}Tc sulfur colloid[36] in patients who had undergone either antethoracic or intrathoracic esophagogastrostomy. And the author also investigated the problem whether pyloroplasty was necessary or not in the cases of selective proximal vagotomy (SPV) for duodenal ulcer from a view point of motility at the gastroduodenal junction.

Materials and Methods

I. Experiments in animals

Healthy, adult mongrel dogs weighing from 7 to 20 kg were used. After fasting over 18 hours, water only permitted, ketamin (Ketalar 50®, Parke Davis & Sankyo) of 10 mg/kg was injected intramuscularly. Then each animal was placed in a supine position on the operative table. A venous root was selected from a lower limb. Initially, pentobarbital (Nembutal®, Abbott Laboratories) of 20 mg/kg was injected intravenously. Then, intratracheal cannulation

Key words: Gastroduodenal manometry, Postoperative gastric motility, Vagotomy, Pyloroplasty, Gastric tube for esophageal reconstruction.
索引語：胃十二指腸内圧測定，術後胃運動機能，迷切，幽門形成術，食道再建用胃管.
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was performed and respiration was controlled by a respirator using room air during investigation. Anesthetic depth was kept as constant as possible with re-injection of pentobarbital of 10 mg/kg when the subject stirred.

A. Manometric studies

For gastroduodenal manometry, the open-tipped catheter (Argyle-Arndorfer-Mcsteen Motility tube, U.S.A.) was connected to a pressure transducer (LPU-0.1 A, Nihon Kohden), a carrier amplifier (RP-5, Nihon Kohden) and a multi-purpose polygraph (RM-45, Nihon Kohden) as shown in Fig. 1. The withdrawal curves were recorded with 0.75 cm/sec of paper velocity. During manometric study, bubble-free distilled water was perfused at a constant rate of 40 ml/hr through the catheter. The catheter was withdrawn in 0.5 cm increments.

After a laparotomy, the catheter was introduced through the mouth into the third portion of the duodenum and detained there. A distance from the upper incisor tooth line to the pyloric ring was measured and had it as a mark in each manometric withdrawal. Ten minutes after detention of the catheter (its interval was prepared in order to exclude hyperperistalsis of the intestine by manipulation), the first withdrawal curve was graphed. After three withdrawals, confirming a reproducibility, the pressure values of HPZ were measured and their mean value was used as preoperative one.

(1) Effects of intravenous injections of various kinds of gastrointestinal hormones and autonomic drugs on HPZ at the gastroduodenal junction

Five minutes after the injection of gastrin (Tetragastrin®, 5 μg/kg, Teikoku Zohki), secretin (Secrepan®, 1 Eisai u/kg, Eisai) or pancreozymin (5 CHR u/kg, Eisai), the pressure value was measured. And also vagostigmine (0.05 mg/kg, Shionogi), atropine (0.5 mg/kg), adrenalin (Bosmin®, 0.2 mg/kg, Daiichi) or imidalin (1 mg/kg, Yamanouchi) was injected intravenously and the pressure value at the gastroduodenal junction was measured after five minutes. The control group was infused with the physiological saline solution intravenously.

(2) Effects of various kinds of pyloroplasties

Various kinds of pyloroplasties, i.e. HEINEKE-MIKULICZ, FINNEY, HORSLEY[9], JUDD[16], HOLLE[8] and MOSCHEL[23] were performed on the pylorus of the normal stomach as shown in

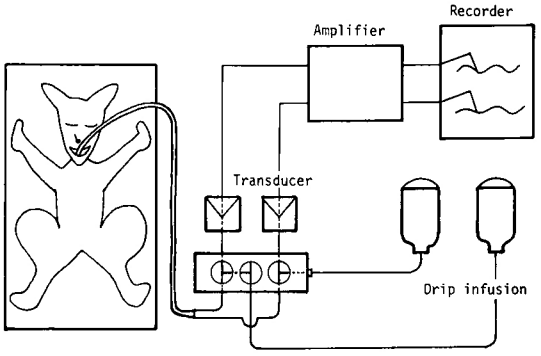


Fig. 1. Apparatus for manometry.

Fig. 2. And also RAMSTEDT pyloromyotomy and pylorectomy according to AUST and WILLENEGGER[30] were done. In HORSLEY pyloroplasty, the longitudinal incision over the pyloric ring was performed straight as in HEINEKE-MIKULICZ method. In JUDD or HOLLE operation, assuming duodenal ulcer was present, a part of duodenal bulbus was excised through entire wall in a cone- or spindle -shape with a part of pylorus. Then, the abdominal wound was closed. After one week, laparotomy was done again and postoperative pressure value was measured as before. The sham-operated dogs were served as the control group.

(3) Effects of vagotomy and splanchnicotomy on HPZ at the gastroduodenal junction

The author divided nine dogs into three groups; vagotomized, splanchnicotomized, and control groups. Bilateral truncal vagotomy was performed subdiaphragmatically through abdominal incision. On the other hand, bilateral splanchnicotomy was done between the diaphragm and the suprarenal gland. One hour after dissection, the pressure value at the HPZ was measured and, in the control group, the measurement was performed two hours after laparotomy. In the long-term experiment, another nine dogs were used and divided into three groups as the short-term experiment. As soon as the nerves were dissected, the abdominal wound was closed. Two weeks later, the dog was re-laparotomized and the pressure value was measured as before.

(4) The change of HPZ at the gastroduodenal junction in various kinds of the gastric tubes

The author investigated the change of HPZ at the gastroduodenal junction of the gastric tubes for esophageal reconstruction and how the pressure value changed in proportion to the size of the gastric tube.

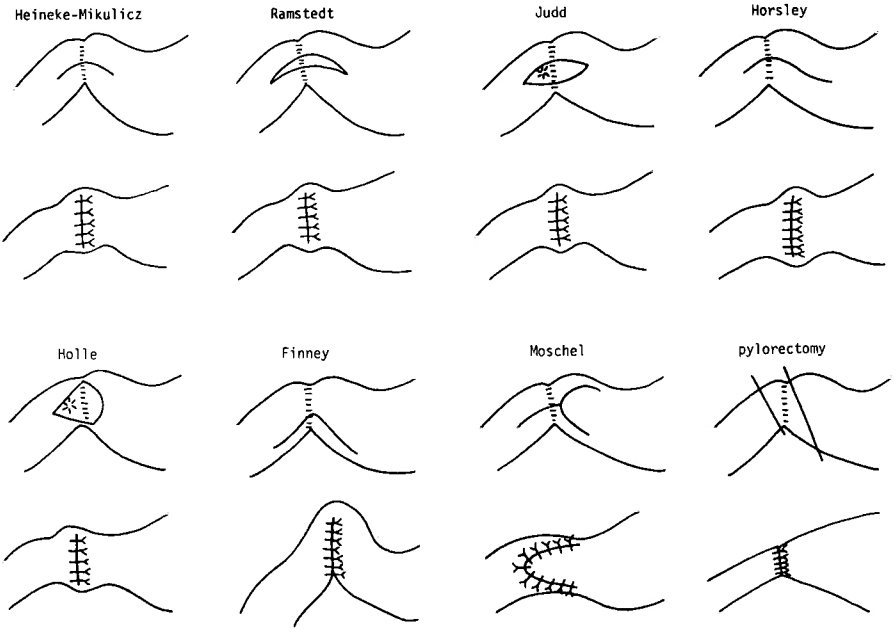


Fig. 2. Various methods of pyloroplasties.

In the short-term experiment, twenty dogs were divided into five groups; small tube with truncal vagotomy (TV), small tube with selective vagotomy (SV), large tube with TV, large tube with SV, and the control group. The small or one-half-sized gastric tube and the large or two-thirds-sized gastric tube were created as shown in Fig. 3. Each of those was mobilized outside of the wound, taking care of no tension on the pyloric region, and was fixed into the subcutaneous tunnel of left caudal chest wall. The open-tipped catheter was inserted through a small bore of chest wall, which was opened into the gastric tube. After one hour, the postoperative pressure value at the gastroduodenal junction was measured.

In the long-term experiment, after the gastric tube was created, it was fixed into the antethoracic subcutaneous tunnel and the residual stomach on the cardiac side was anastomosed to the proximal jejunum with Billroth II method. As soon as the operation was finished, the abdominal wound was closed. Two weeks after the operation, laparotomy was performed again and the pressure value at the gastroduodenal junction was measured as formerly. Twelve dogs survived and served in the long-term experiment.

(5) Experiments to investigate the necessity of pyloroplasty at the time of SPV

Nine dogs were divided into three groups; SPV, SPV with pyloroplasty, and the control group. Two weeks postoperatively, the author investigated the change of HPZ at the gastroduodenal junction.

B. Electromyographic studies

For investigation of the alteration in the electrical activity of various kinds of the gastric tubes, the author divided eleven dogs into four groups; non-vagotomized (Tr) group, total vagotomized (Tr with TV) group, selective vagotomized (Tr with SV) group, and the control group. And the frequency of antiperistaltic discharge was measured. A gastric transection was performed oral to a point where the antral branch anchored to the gastric wall. The bipolar needle electrode (the interpolar distance was 2 mm), with its tip inserted into the muscle layer, sutured to the anterior serosal surface near the greater curvature of the gastric tube. The first

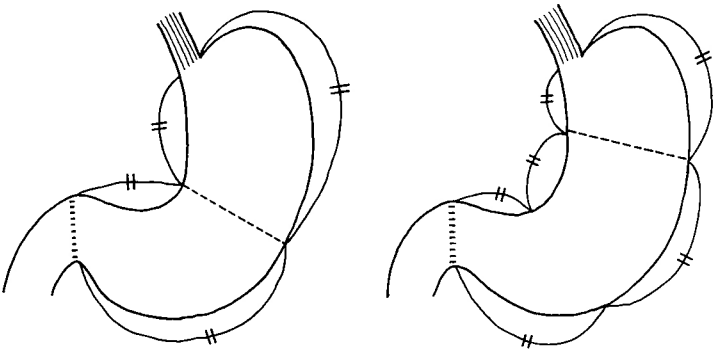


Fig. 3. Various methods of creating gastric tubes with or without dissection of hepatic branch, i.e. TV or SV. The small tube is one-half and the large tube is two-thirds of the full stomach.

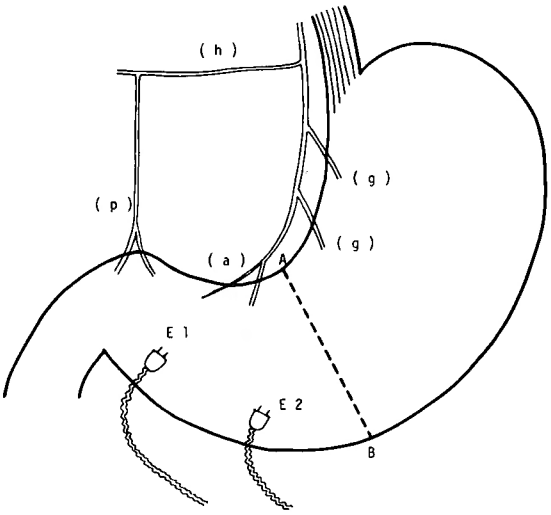


Fig. 4. Sites of gastric transection and attachment of each electrode.
AB: transected line, El: distal electrode near the pyloric ring, E2: proximal electrode 4 to 5cm oral to E1, (a): antral branch, (g): gastric branch, (h): hepatic branch, (p): pyloric branch.

electrode was placed near the pyloric ring and the second 4 to 5 cm oral to the first one as shown in Fig. 4. Each electrode was connected to an amplifier (ELECTROMYOGRAPH MEM-3102, Nihon Kohden) and electrical motility was recorded with multi-purpose polygraph (RM-45, Nihon Kohden). The paper velocity was adjusted to 3 mm/sec and the time constant was 0.003 sec. An indifferent electrode was placed subcutaneously in the abdominal wall.

The short-term experiment was performed one hour after operation and the long-term experiment was done two weeks later. The fixation of the gastric tube and the anastomosis between the proximal stomach and the jejunum were performed in the same manner as manometric study.

II. Clinical studies

(1) The postoperative pressure values of HPZ in patients who had undergone esophageal reconstruction

In patients who had undergone either intrathoracic or antethoracic esophagogastrostomy after resection of esophageal cancer, the pressure values at the gastroduodenal junction were measured approximately three months after operation. The open-tipped catheter, the modified SAITO doublelumen gastro-intestinal tube (SUGIYAMA GORO Shoten) for manometry, was introduced pernasally into the third portion of the duodenum under direct fluoroscopic visualization after the fasting of at least twelve hours. The gastroduodenal junction was recognized by fluoroscopy with a small amount of Gastrografin[8] and a distance from the naris to the gastroduodenal junction was measured. The catheter was connected to the apparatus for manometry. Subsequently, the withdrawal curve of HPZ was graphed.

(2) Half emptying time measurement of the contents of the gastric tube (gastrogram)

The same patient, received manometric study, was given a meal of 200 g of rice-gruel

contained 2 mci of ^{99m}Tc sulfur colloid and the time of ingestion of the meal averaged five minutes. Then, the patient sat on a chair and his chest was contact with gamma camera and a scinti-scanning was started. The half emptying time ($T^{1/2}$) was measured.

Results

I. Experiments in animals

A. Manometric studies

In the duodenum, the withdrawal curves showed fairly rapid, flat ones. After a while, HPZ at the gastroduodenal junction was graphed, characterized with either urgent or mild rising (Fig. 5). Still more withdrawn the catheter, the antral peristaltic wave was recorded, showing slow rhythm but fairly high amplitude. Usually the intraluminal pressure was higher, 1.5 to 4.5 cm H_2O, at the antrum than at the duodenal bulbus. Intraduodenal pressure was used as a zero reference. Based on these matters, the following results were obtained.

In mongrel dogs, the gastroduodenal junction was characterized as HPZ with an amplitude of 23.7 ± 1.04 cm H_2O ($\bar{X} \pm$SEM, n=82) and a length of 0.5 to 1.5 cm (Table 1).

(1) Effects of various kinds of gastrointestinal hormones and autonomic drugs

Five minutes after the intravenous injection of gastrin, the pressure value of HPZ significantly increased by $79.7 \pm 17.19\%$ as compared with the value before the injection ($t=4.63$, $p<0.05$, n=3). But after the intravenous injection of secretin and pancreozymin, the pressure values showed a decrease of $55.6 \pm 7.80\%$ ($t=7.13$, $p<0.05$, n=3) and of $38.4 \pm 8.40\%$ ($t=4.57$, $p<$

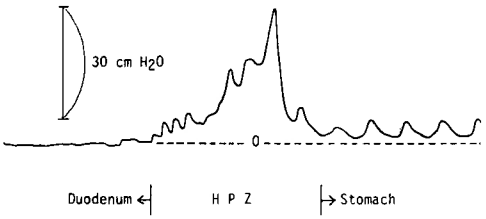


Fig. 5. Withdrawal manometry curve at the gastroduodenal junction. Intraduodenal pressure was used as a zero reference.

Table 1. Pressure values of HPZ at the gastroduodenal junction.

Investigator	Pressure value	Subject
Brody	not detectable	human
Atkinson	not detectable	human
Andersson	not detectable	human
Kaye	not detectable	human
Brink	3.2 cm H_2O	dog
Fisher	7.2 cm H_2O	human
Isenberg	14.8 cm H_2O	dog
Valenzuela	13.8 cm H_2O	human
the author	23.7 cm H_2O	dog

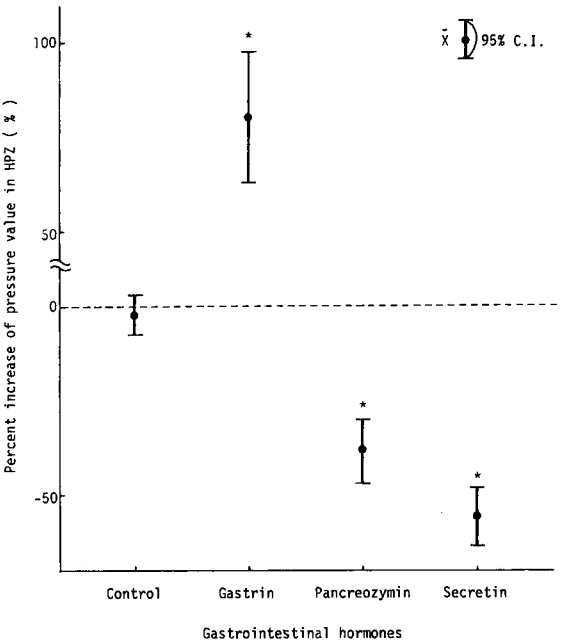


Fig. 6. Changes of HPZ after injection of gastrointestinal hormones.
$\bar{X}$: mean value, C.I.: confidence interval, *: $p<0.05$ vs control.

0.05, n=3), respectively, as shown in Fig. 6. Vagostigmine tended to increase but adrenalin tended to decrease these values after injection. Both atropine and imidalin did not result in any change (Fig. 7).

(2) Effects of various kinds of pyloroplasties

One week after operations of eight groups, all kinds of pyloroplasties decreased the pressure

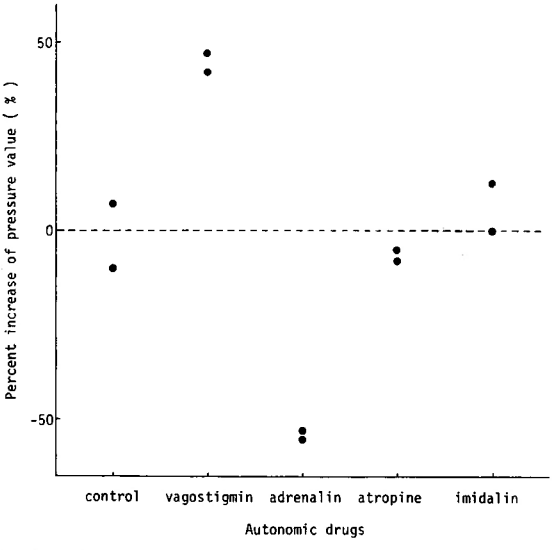


Fig. 7. Changes of HPZ after injection of autonomic drugs.

values at the gastroduodenal junction as compared with preoperative ones as depicted in Fig. 8 and 9. Pylorectomy decreased the pressure by 95%; HORSLEY pyloroplasty by 50.5%; FINNEY pyloroplasty by 49.5%; HEINEKE-MIKULICZ pyloroplasty by 47.5%; RAMSTEDT pyloromyotomy by 36.5%; JUDD pyloroplasty by 35%; MOSCHEL pyloroplasty by 26%; and HOLLE pyloroplasty by 25% (Fig. 10).

(3) Effects of vagotomy and splanchnicotomy

After bilateral truncal vagotomy, the tonus of the wall of the stomach and gastroduodenal

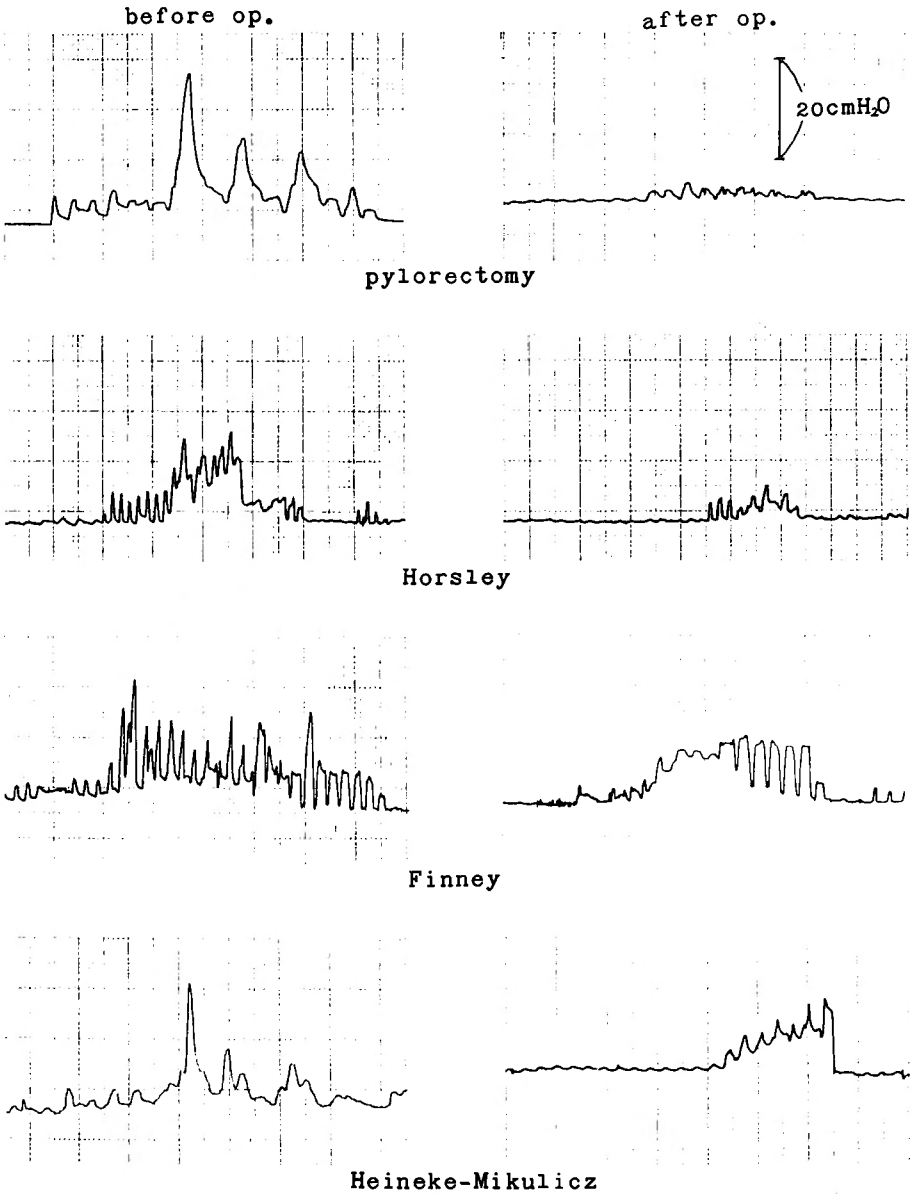


Fig. 8. Profiles of withdrawal curves after various kinds of pyloroplasties (part 1).

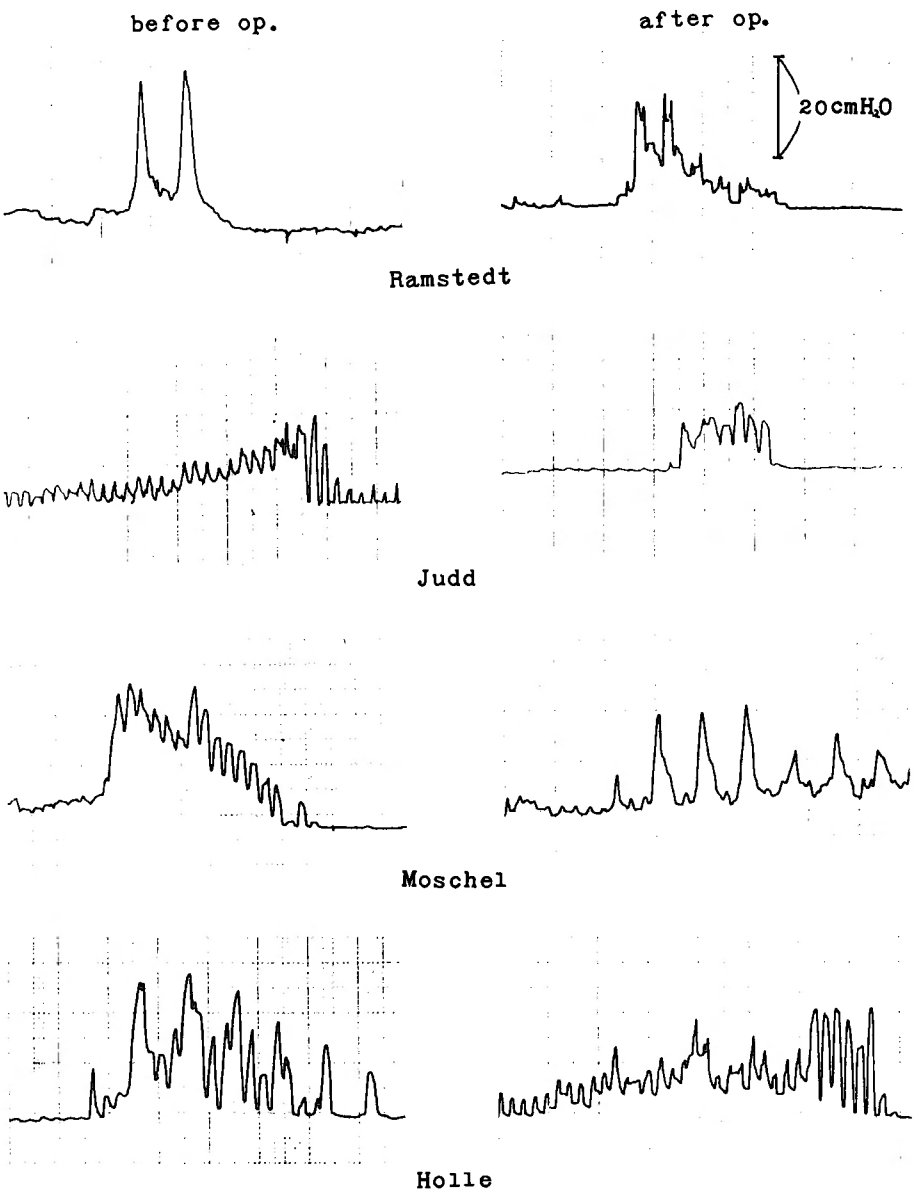


Fig. 9. Profiles of withdrawal curves after various kinds of pyloroplasties (part 2).

junction were weakened. Vagotomy did not change systemic blood pressure, which was measured by cannulation in the right femoral artery. One hour later, the tonus of the wall continued to be weakened and the pressure values significantly decreased by $49.1 \pm 5.53\%$ ($t=9.14$, $p<0.05$, $n=3$) as shown in Fig. 11 and Table 2. On the other hand, bilateral splanchnicotomy strengthened the tonus of the wall and decreased systemic blood pressure. And also it increased significantly the pressure by $72.0 \pm 14.95\%$ ($t=4.82$, $p<0.05$, $n=3$). In Fig. 12, the practical withdrawal curves were depicted.

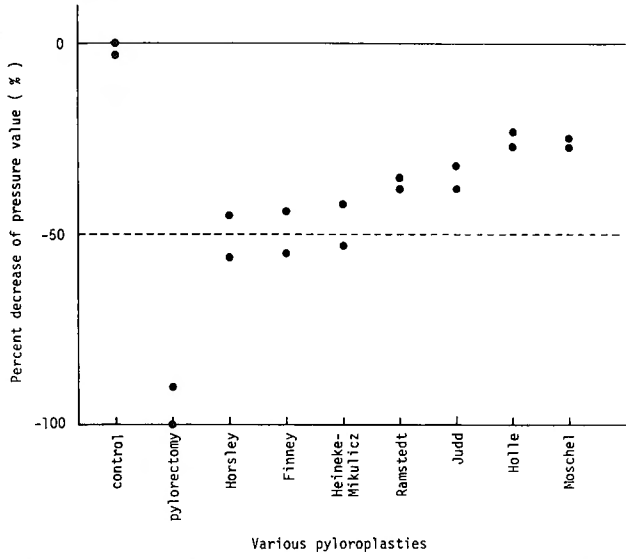


Fig. 10. Comparison in decompressive effects of pyloroplasties.

In the long-term experiment, the abdomen was opened again after two weeks. The antral wall showed the strengthened tonus and as shown in Table 3, the pressure values at the gastroduodenal junction increased significantly by $173 \pm 37.1\%$ as compared with preoperative ones

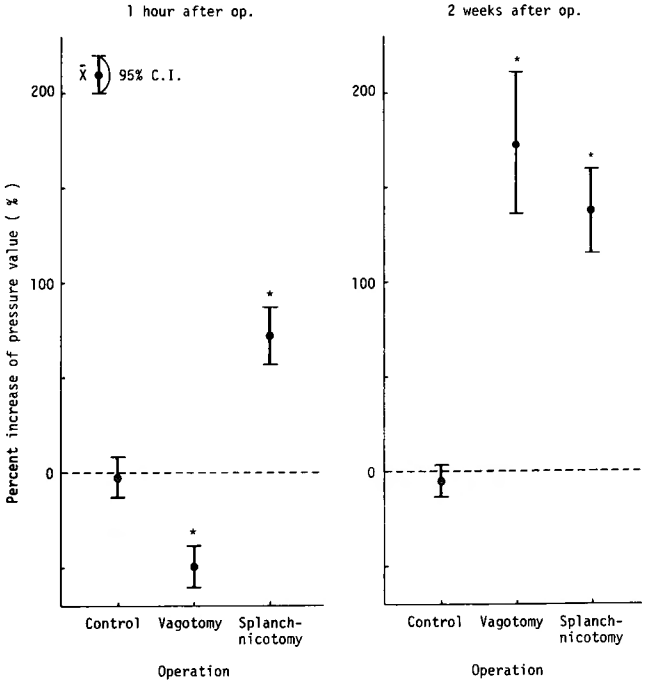


Fig. 11. Changes of HPZ after truncal vagotomy or splanchnicotomy.
$\bar{X}$: mean value, C.I.. confidence interval, *: $p<0.05$ vs control.

Table 2. Changes of HPZ after vagotomy or splanchnicotomy (short-term experiment).

Group	Before operation cm H_2O	After operation cm H_2O	Difference cm H_2O	Percent increase %
Vagotomized	25.0±3.46*	12.7±2.19	12.3±2.19	−49.1±5.53
Splanchnicotomized	18.3±2.67	31.0±3.79	12.7±2.33	72.0±14.95
Control	18.0±2.52	17.3±1.76	0.7±0.88	−2.4±5.25

*: value of mean±SEM

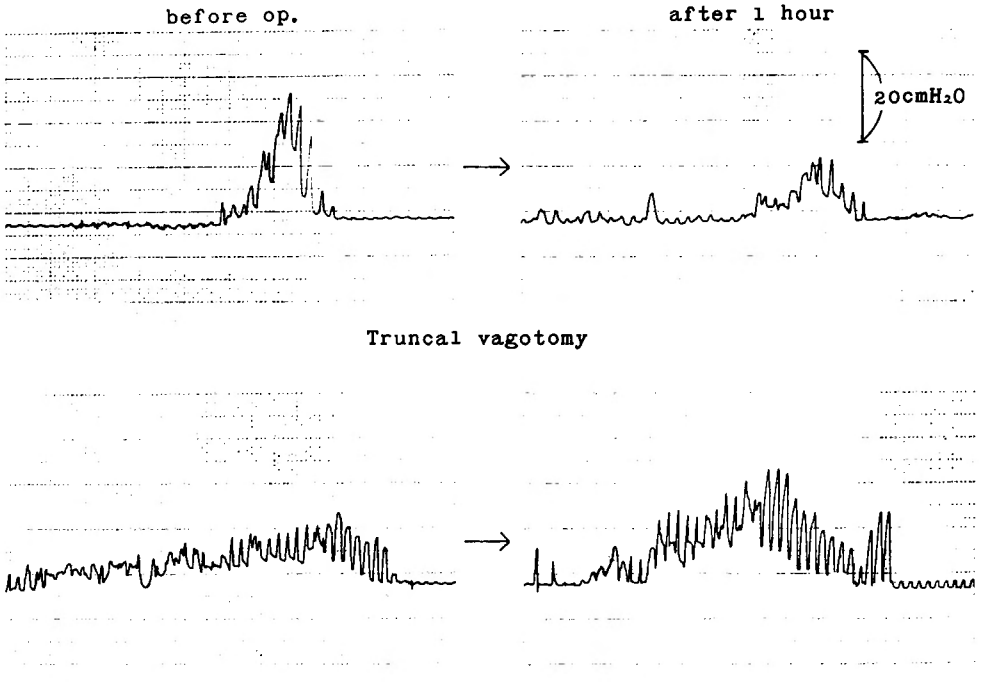


Fig. 12. Profiles of HPZ after truncal vagotomy or splanchnicotomy (short-term experiment).

Table 3. Changes of HPZ after vagotomy or splanchnicotomy (long-term experiment).

Group	Before operation cm H_2O	After operation cm H_2O	Difference cm H_2O	Percent increase %
Vagotomized	12.7±1.20*	35.3±7.51	22.7±6.39	173.3±37.12
Splanchnicotomized	17.3±5.84	38.7±8.74	21.3±2.96	138.1±22.77
Control	27.7±8.17	27.7±5.67	0.0±2.52	−4.8± 8.26

*: value of mean±SEM

($t=4.67$, $p<0.05$, $n=3$). While in the splanchnicotomized group, the tonus were not so strengthened but the pressure values increased by 138±22.8% ($t=6.06$, $p<0.05$, $n=3$). Practical withdrawal curves were depicted in Fig. 13.

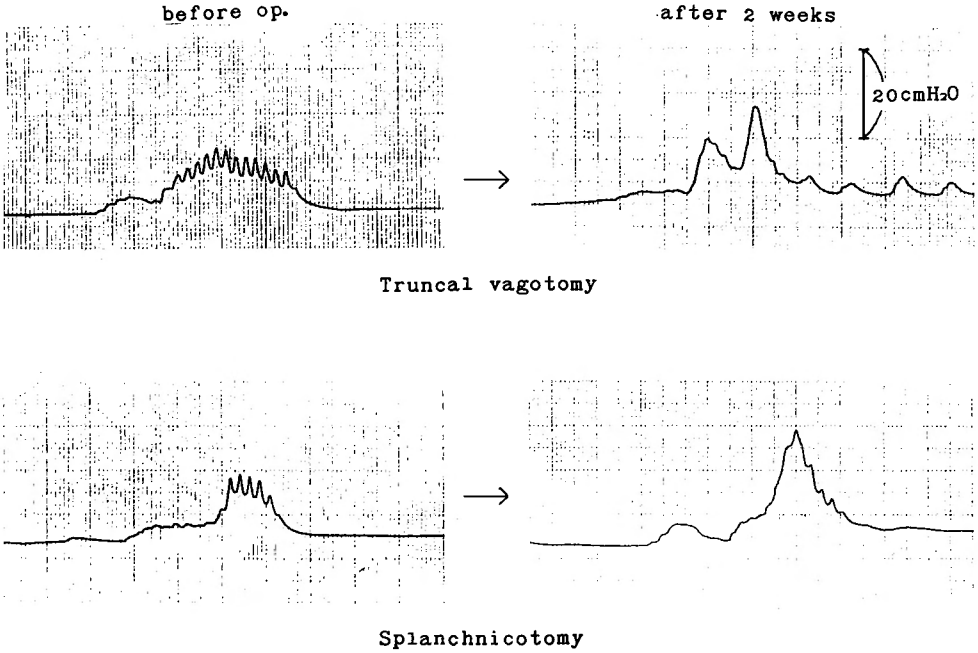


Fig. 13. Profiles of HPZ after truncal vagotomy or splanchnicotomy (long-term experiment).

(4) Changes of HPZ at the gastroduodenal junction in the gastric tubes

In the short-term experiment after the creation of a gastric tube with TV, the pressure values at the gastroduodenal junction increased significantly by $34.8\pm8.95\%$ in the small tube group ($t=3.88$, $p<0.05$, $n=5$) and by $17.5\pm7.17\%$ in the large tube group ($t=2.44$, $p<0.10$, $n=5$) as shown in Fig. 14 and Table 4. The withdrawal curves were depicted in Fig. 15. Moreover,

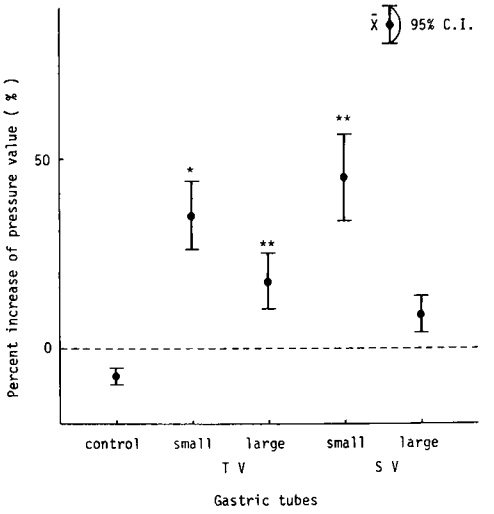


Fig. 14. Changes of HPZ in gastric tubes with TV or SV (short-term experiment).
$\bar{X}$: mean value, C.I.: confidence interval, *: $p<0.05$, **: $p<0.10$ vs control.

Table 4. Changes of HPZ in the created gastric tubes (short-term experiment).

Group	Before operation cm H_2O	After operation cm H_2O	Difference cm H_2O	Percent increase %
Small tube with TV	22.0±2.24*	29.2±3.12	7.2±1.89	34.8± 8.95
Large tube with TV	22.6±2.79	26.2±2.73	3.6±1.40	17.5± 7.17
Small tube with SV	13.7±5.78	18.7±6.77	5.0±1.00	44.9±11.43
Large tube with SV	28.7±9.21	30.3±9.05	1.7±0.17	8.8± 4.72
Control	20.5±2.66	19.0±2.48	1.5±0.29	−7.3± 1.07

*: value of mean±SEM, TV: truncal vagotomy, SV: selective vagotomy.

in the long-term experiment, the pressure values increased by 122.9±18.18% ($t=6.76$, $p<0.01$, $n=4$) and by 83.9±24.78% ($t=3.39$, $p<0.05$, $n=4$), respectively, as shown in Fig. 16 and Table 5. In Fig. 17, the withdrawal curves were depicted. The practical percent increases in pressure values were described in Table 6. The values increased more distinctly in the long-term experiment than in the short-term experiment ($F=28.09$, $p<0.01$), while the small tube group showed an higher increase rather than the large tube group ($F=3.36$, $p<0.10$) as shown in Table 7. On the other hand, in the gastric tube with SV group, the pressure values of both the small and large tubes (respectively $n=3$) increased as like as in TV group, but the difference was not recognized between two groups.

(5) Experiments to investigate the necessity of pyloroplasty at the time of SPV

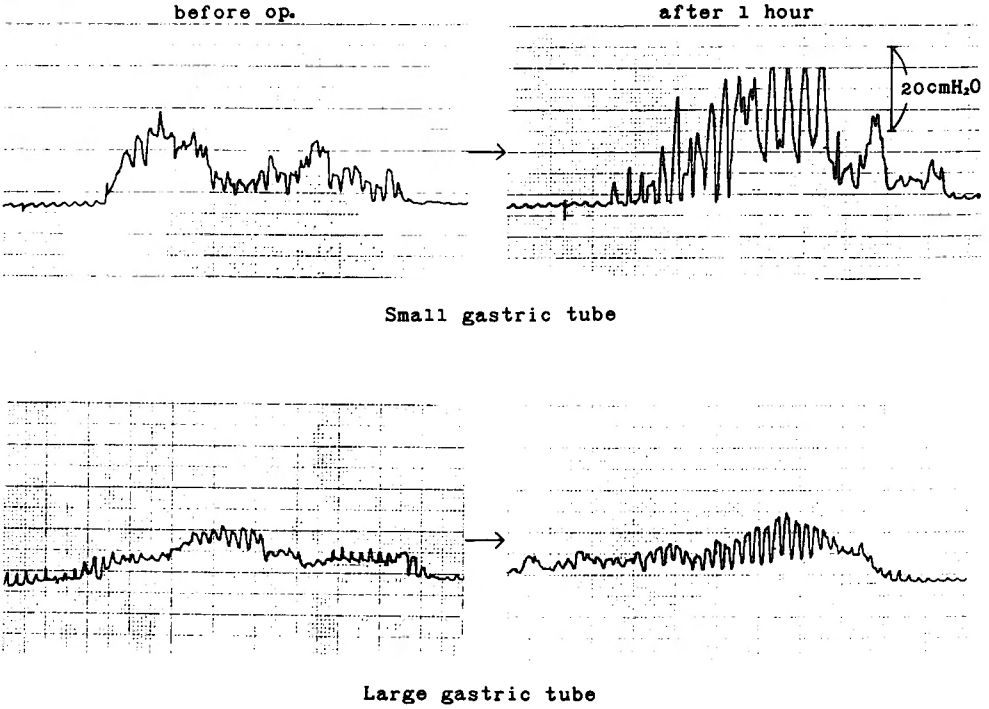


Fig. 15. Profiles of HPZ after creating gastric tubes with TV (short-term experiment).

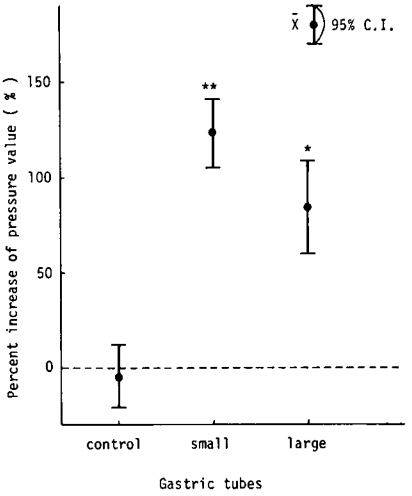


Fig. 16. Changes of HPZ in gastric tubes with TV (long-term experiment).
$\bar{X}$: mean value, C.I.: confidence interval, *: $p<0.05$, **: $p<0.01$ vs control.

The author selected FINNEY's method as pyloroplasty because its decompressive effect was fairly high. The withdrawal curves were depicted in Fig. 18. There was no difference of pressure values at the gastroduodenal junction between SPV group and the control group as shown in Fig. 19 and Table 8. But in SPV group with FINNEY pyloroplasty, the pressure values decreased significantly ($t=9.26$, $p<0.05$).

B. Electromyographic studies

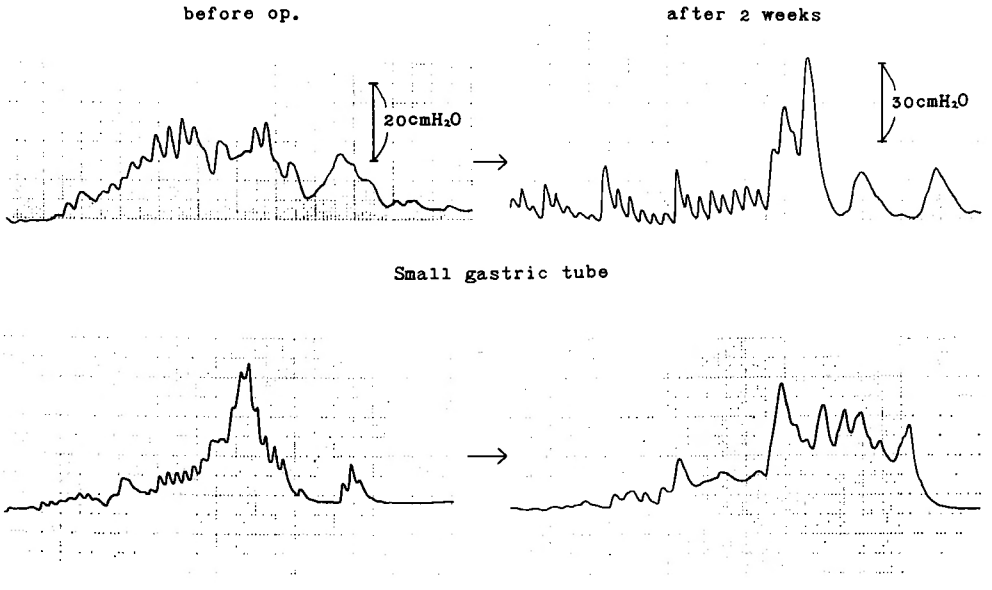


Fig. 17. Profiles of HPZ after creating gastric tubes with TV (long-term experiment).

Table 5. Changes of HPZ in the created gastric tubes (long-term experiment).

Group	Before operation cm H_2O	After operation cm H_2O	Difference cm H_2O	Percent increase %
Small tube with TV	23.3±2.63*	51.5±6.99	28.3±5.33	122.9±18.18
Large tube with TV	25.5±5.42	43.3±4.01	17.8±1.93	83.9±24.78
Control	27.7±8.17	27.7±5.67	0.0±2.52	−4.8± 8.26

*: value of mean±SEM. TV: truncal vagotomy.

Table 6. Per cent increases of pressure values at the gastroduodenal junction after creating gastric tube.

Group	After 1 hour			After 2 weeks	
Small tube with TV	32.00	47.05	24.13	69.23	137.50
	9.52	61.11		150.00	134.70
Large tube with TV	10.71	13.33	45.00	51.85	39.50
	15.00	3.33		100.00	146.60

TV: truncal vagotomy

In Table 9, the electromyographic data are described. One of three dogs in the Tr group died, therefore two dogs served in the long-term experiment. For the judgment of antiperistaltic discharge, the author referred to the direction of propagation and the polarity of discharge which differed with normoperistaltic discharge as shown in Fig. 20.

In the short-term experiment, the frequency of antiperistaltic discharges was 96±1.8% in

Table 7. Analysis of variance table.

SV	SS	DF	V	F	p
Size of created gastric tube	3197	1	3197	3.3580	<0.10
Time at measurement after op.	26739	1	26739	28.0852	<0.01
Error	14281	15	952		
Total	44217	17			

SV: source variation, SS: sum of square, DF: degree of freedom, V: variance, F: F value, p: probability.

Table 8. Changes of HPZ after SPV+Finney's pyloroplasty.

Group	Before operation cm H_2O	After operation cm H_2O	Difference cm H_2O	Percent increase %
SPV	30.3±10.84*	31.0±9.45	0.7±1.45	9.6±10.43
SPV+F	37.7±2.40	22.0±2.08	15.7±2.19	−41.5±4.48
Control	27.7±8.17	27.7±5.67	0.0±2.52	−4.8±8.26

*: value of mean±SEM, SPV: selective proximal vagotomy, F: Finney's pyloroplasty.

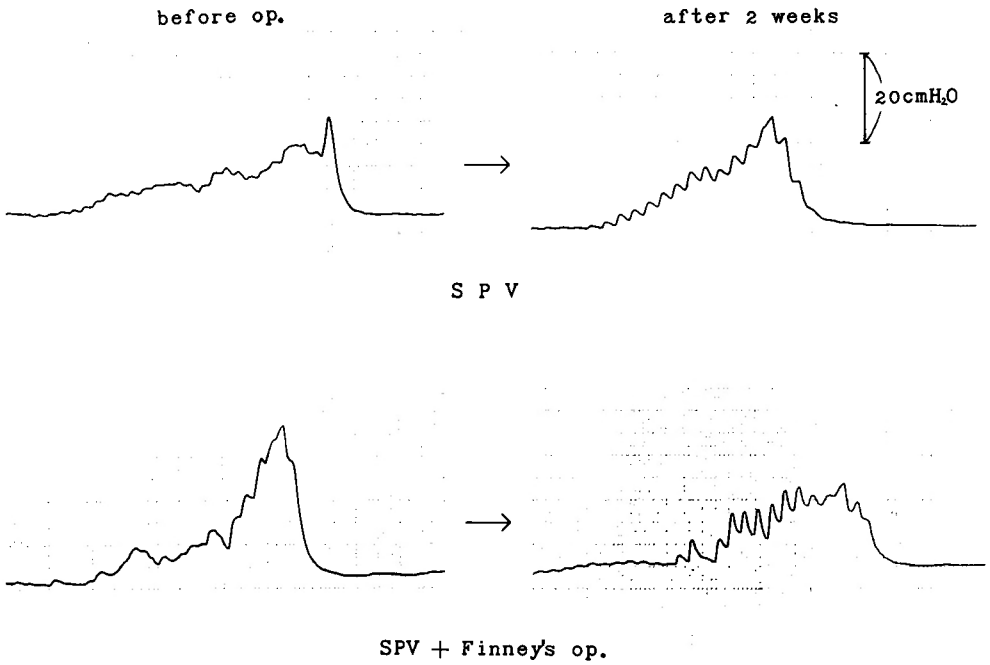


Fig. 18. Profiles of withdrawal curves after SPV±Finney pyloroplasties.

Tr with SV group (n=3), 47±3.4% in Tr with TV group (n=3), and 2±0.8% in Tr group (n=3). There was distinct difference between Tr with SV group and Tr with TV group (χ^2=80.46, $p<0.01$). And in the long-term experiment, these values decreased respectively ($p<0.01$). On the other hand, in Tr group, the antiperistaltic discharges did not change in either the short-

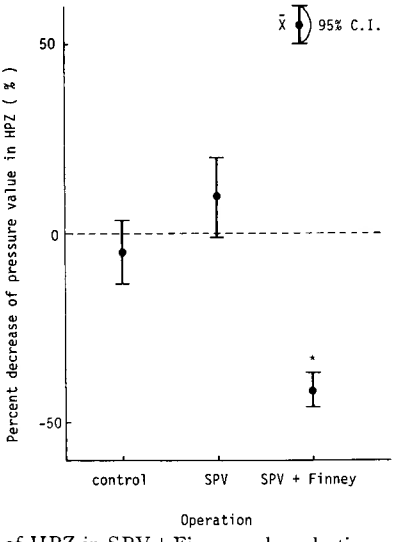


Fig. 19. Changes of HPZ in SPV±Finney pyloroplasties.
$\bar{X}$: mean value, C.I.: confidence interval, *: $p<0.05$ vs control.

Table 9. Frequency of antiperistaltic discharges and table of χ^2.
The frequency was presented as antiperistaltic discharges/total discharges.

Group	After 1 hour	After 2 weeks	χ^2
Tr+SV	119/124 (96±1.8)	4/318 (1±0.6)	393.7**
Tr+TV	91/193 (47±3.4)	74/218 (34±3.2)	7.429**
Tr	6/311 (2±0.8)	1/137 (0.7±0.08)	0.2805
Control	2/236 (1±0.6)	0/140 (0.0)	0.1288

( ): %±SEM

After 1 hour

Tr+SV	325.4**		
Tr+TV	131.3**	80.46**	
Tr	0.4682**	382.8**	156.7**
	Control	Tr+SV	Tr+TV

After 2 weeks

Tr+SV	0.6207		
Tr+TV	57.85**	108.5**	
Tr	6.372*	0.0029	53.72*
	Control	Tr+SV	Tr+TV

*: $p<0.05$, **: $p<0.01$, Tr: gastric transection, TV: truncal vagotomy, SV: selective vagotomy.

Table 10. Clinical data
These data were obtained 3 months after operation.

Antethoracic reconstruction

Patient	Pressure value of HPZ cm H_2O	$T^{1/2}$ in gastrogram min
1 S.N. 53 M	10.5	29.0
2 T.N. 69 M	4.5	7.0
3 S.N. 69 F	10.0	27.2
4 M.S. 50 M	10.5	—
5 I.M. 59 M	16.5	—
6 K.S. 49 F	12.0	—
7 M.I. 75 M	19.0	—
8 K.I. 50 M	7.0	—
9 T.W. 46 M	—	37.5
10 M.I 68 M	—	30.0
Total 10	11.3±1.66*	26.1±5.09

Intrathoracic reconstruction

Patient	Pressure value of HPZ cm H_2O	$T^{1/2}$ in gastrogram min
1 Y.S. 69 F	26.0	—
2 H.I. 64 M	16.5	24.0
3 E.M. 52 M	12.0	42.5
4 J.I. 75 M	14.0	23.7
Total 4	17.1±3.09	30.1±6.22

*: mean±SEM

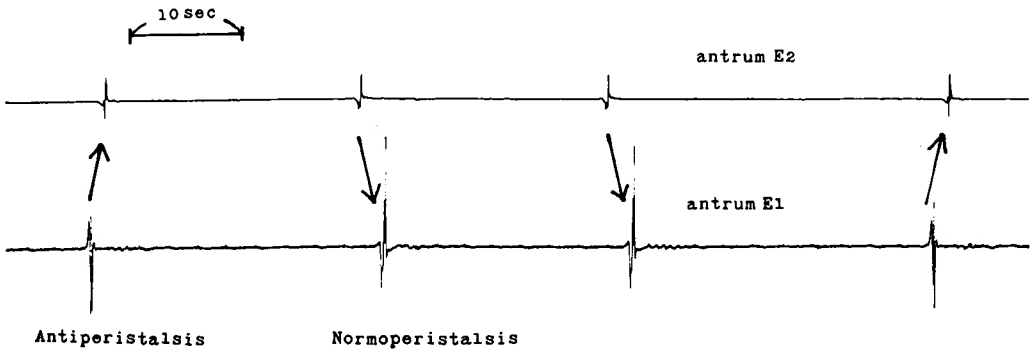


Fig. 20. Anti- or normoperistaltic discharge in the antrum of created gastric tube. The difference was referred to the direction of propagation and polarity of discharge.

or the long-term experiment.

II. Clinical studies

The postoperative clinical data were described in Table 10. Three months after operation, the pressure value at the HPZ was 17.1±3.09 cm H_2O in patients who had undergone intrathoracic esophagogastrostomy with HEINEKE-MIKULICZ pyloroplasty. On the other hand, the pressure value was 11.3±1.66 cm H_2O in patients who had undergone antethoracic esophagogastrostomy with RAMSTEDT pyloromyotomy. The withdrawal curve in each case was presented in Fig. 21.

In gastrogram, the value of $T^{1/2}$ was 30.1±6.22 minutes in the intrathoracic reconstruction

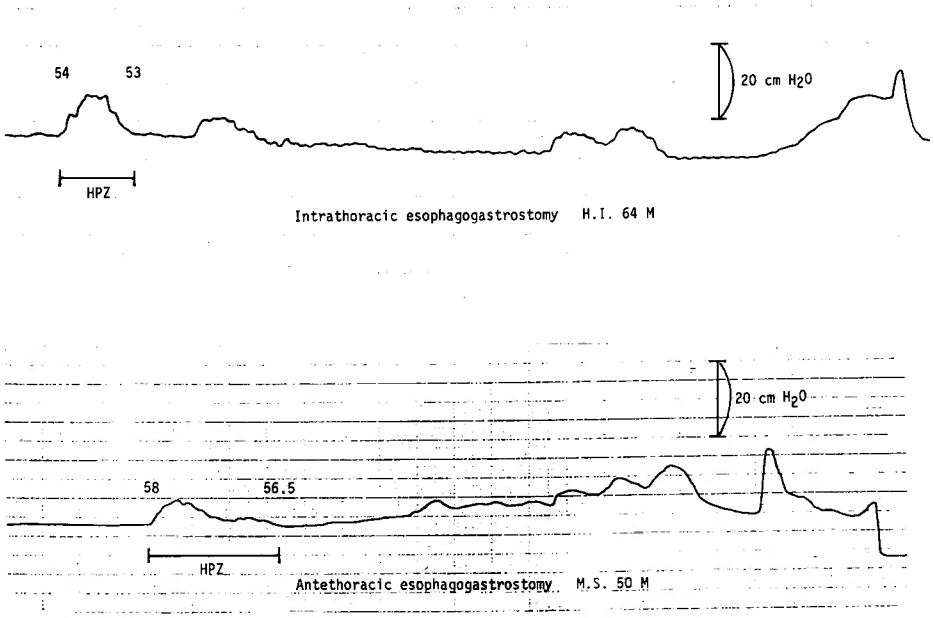
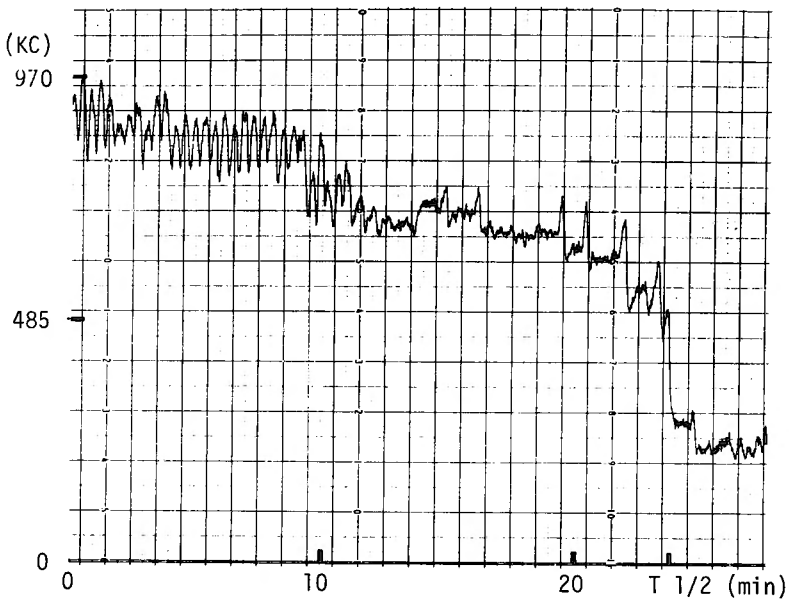
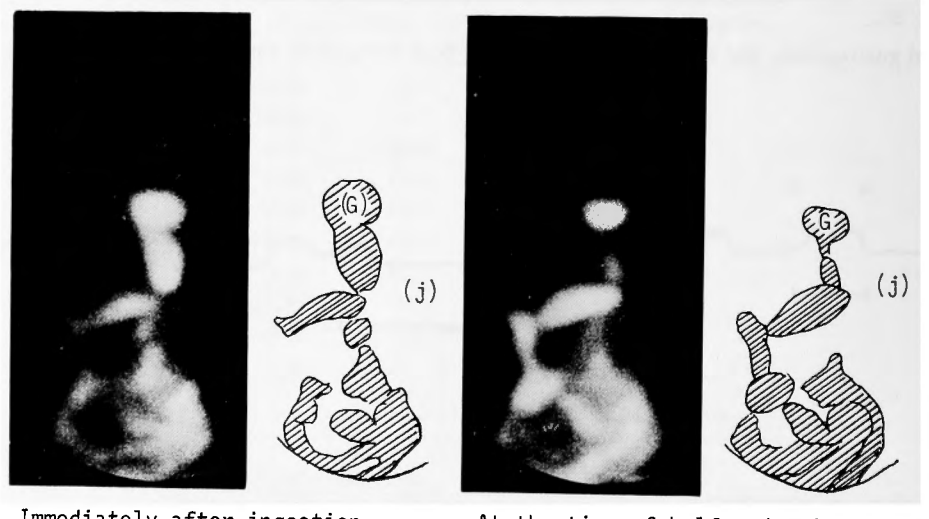


Fig. 21. Profile of withdrawal curve at the gastroduodenal junction in a patient who had undergone intra- or antethoracic esophagogastrostomy before 3 months.



Profile of gastrogram.
Half emptying time was 23.7 min.

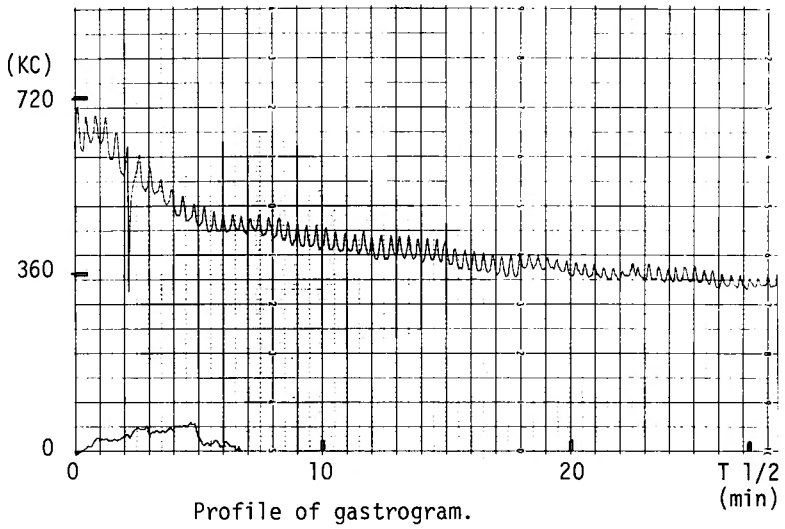


Immediately after ingestion At the time of half reduction

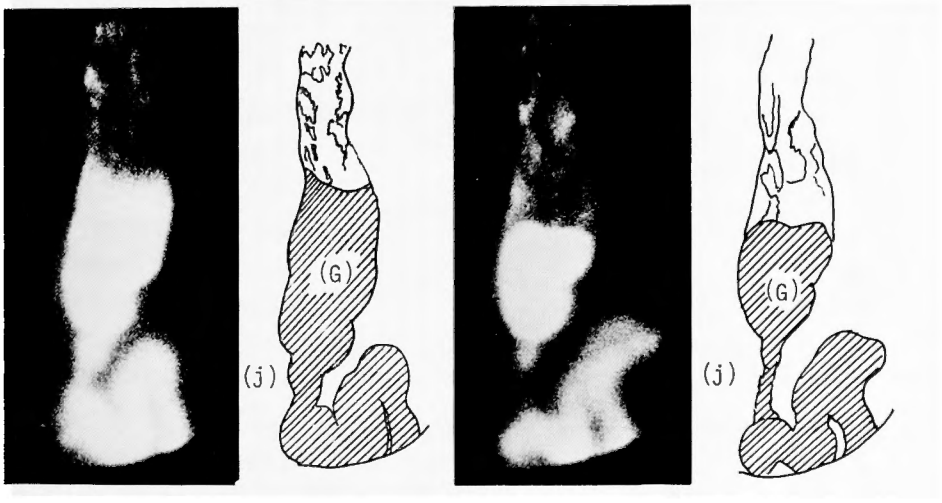
Fig. 22. Profile of gastrogram and photos of gamma camera in a patient who had undergone intrathoracic esophagogastrostomy.
(G): Gastric tube, (j): Gastroduodenal junction

group and 26.1±5.09 minutes in the antethoracic reconstruction group. Fig. 22 or 23 shows each prolfie of gastrogram and photos by means of gamma camera in patients who had undergone intrathoracic and antethoracic esophagogastrostomies.

On the other hand, in the small number of the patients who had undergone intrathoracic



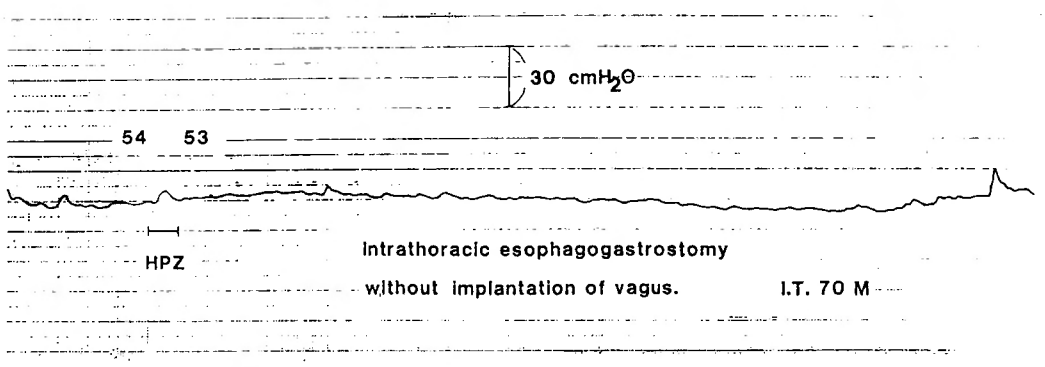
Profile of gastrogram.
Half emptying time was 27.2 min.



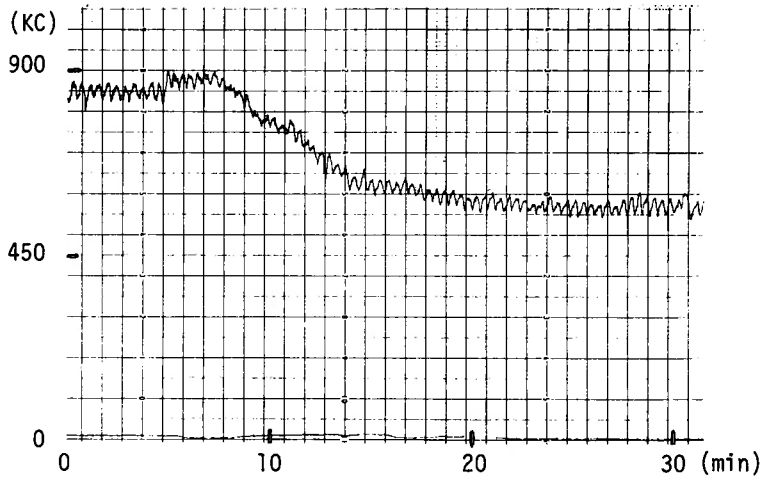
Immediately after ingestion At the time of half reduction

Fig. 23. Profile of gastrogram and photos of gamma camera in a patient who had undergone antethoracic esophagogastrostomy.
(G): Gastric tube, (j): Gastroduodenal junction

esophagogastrostomy, the implantation of the vagus nerves into the wall of the gastric tube[14] was not possible to perform because of the cancerous invasion into the vagus nerves. In these patients, the postoperative pressure values were near zero cm H_2O (n=2) and $T_{1/2}$ also prolonged as presented in Fig. 24. The author considered that HPZ at the gastroduodenal junction was not presented postoperatively.



Profile of withdrawal curve at the gastroduodenal junction. The pressure value of HPZ was near zero cmH_2O.



Profile of gastrogram. T 1/2 prolonged over 30 min.

Fig. 24. Profiles of withdrawal curve and gastrogram in a patient who had undergone intrathoracic esophagogastrostomy without implantation of the vagus nerves into the gastric wall.

Discussion

The HPZ at the gastroduodenal junction or the pylorus in human subject or animal had been studied, especially in Europe and America (Table 1). BRODY[5], ATKINSON[3], ANDERSSON[2] et al reported that there was no HPZ in man after a fast. And also KAYE[17], using perfused catheter system, observed the human pylorus was not reliably demonstrable as a HPZ. For this reason, ATKINSON described that the bore of the pyloric channel must have been at least 7 mm either after fasting or with food in the stomach and KAYE indicated, basing on endoscopic observations, that the pylorus was open for most of the time in a fasting healthy young individual.

On the other hand, BRINK[4], using both balloon and open-tipped methods, reported that a zone of elevated pressure was detected in the gastroduodenal junction and it had showed different motility from the antrum. Moreover, FISHER[6], ISENBERG[13] and VALENZUELA[39] also detected a HPZ. Especially, FISHER et al indicated the HPZ was narrow and of low resting magnitude and these characteristics might explain the failure of previous investigators and their balloon technique might have been unsuitable for observation.

As depicted in Fig. 5, the withdrawal curve was consisted of three waves. In this study, the segment of higher pressure between the duodenum and the antrum was defined as the HPZ at the gastroduodenal junction. The responses of this zone to various kinds of gastrointestinal hormones and autonomic drugs[18] were similar to those of gastric peristalsis. Therefore, the author considered that this HPZ includes the antral peristaltic wave. MAKI and SHIRATORI[19] denied specific characteristics of pyloric sphincter system and presumed that sphincteric action of the pyloric ring related to anatomical narrowness of canal and the strength of antral peristalsis. The author also agrees with them.

According to FISHER's observations[7], gastrin did not significantly affect the pressure value at the gastroduodenal junction but both secretin and pancreozymin increased it significantly. This result was different from the author's. The author considered this reason to be that the HPZ graphed by this manometry system was affected with antral motility, having no specific function. FISHER also investigated the effect of gastrointestinal hormone on the length of maximum active tension development, using the pyloric muscle strip of the opposum, and these results confirmed their manometric studies. It is so appraisable, but in Japan, many investigators as MAKI[19] and OI[28] concluded that the pyloric ring had no specific function. Regarding the effects of autonomic drugs on the pressure values at the gastroduodenal junction, vagostigmine increased pressure and adrenalin decreased it. These phenomena reflected the stimulation or inhibition of antral motility, respectively. On the other hand, both atropine and imidalin did not affect it. It was suggested that these drugs had no direct reaction on the motility of the gastroduodenal junction.

The effects of various kinds of pyloroplasties were almost identical except pylorectomy. But HORSLEY, FINNEY and HEINEKE-MIKULICZ methods tend to more effectively decrease pressure than the other methods. These results indicated that the pyloric ring, characterized by congenital narrowness, dilated and the antrum relaxed after pyloroplasty. Many investigators[19,26,28,37] reported that in the normal stomach every pyloroplasty had no significance. OI[28] stated that pyloroplasty increased evacuation due to gravity but decreased evacuation due to peristalsis. And also NARUMI[26] reported that gastric emptying occurred with contraction of the pyloric sphincter rather than with relaxation. From the view point of these reports, the author's results had no relation to gastric emptying rate. But it was suggested that the effect of dilated pyloric ring on gastric evacuation was significant under the condition where a motility of residual stomach was inhibited as in fundusectomy or truncal vagotomy[19,26,37]. Of this reason, MAKI[20] studied by means of electromyogram and explained as follows; a pyloroplasty decreased the antiperistalsis which had occurred at the pylorus after the gastric transection.

On the other hand, NAGAO[24] et al described that the antiperistalsis was not prevented by pyloroplasty after ingestion of solid food in dogs. At any rate, it was highly interesting as to the effect of pyloroplasty.

After bilateral truncal vagotomy, the pressure value at the gastroduodenal junction decreased in the short-term experiment. But in the long-term experiment, the value increased remarkably. A few investigators[21,24] reported that the hypofunction of gastric motility was seen after vagotomy as well as after gastric transection or fundusectomy. It is thought that in the short-term experiment the decrease of pressure value referred to gastric atony, but in the long-term experiment the increase of pressure at the gastroduodenal junction was accompanied with the elevated intraluminal pressure of the stomach due to gastric stasis. On the other hand, TSUHADA[37] and IKEDA[10,11] stated that the "Receptive relaxation" disappeared after vagotomy and the elevation of intraluminal pressure of the stomach occurred with the increase of gastric content in either the short- or the long-term experiment. So it is estimated that the pyloric dysfunction after vagotomy arose owing to various factors. Regarding the gastric motility after splanchnicotomy, it is thought that hyperfunction occurred as MAKI and SHIRATORI[22] et al stated. Moreover, it is described that the intense peristalsis may occur in the pyloric ring[18]. IKEDA[10,11] also indicated the disappearance of the "Receptive relaxation" had occurred after splanchnicotomy. The author thinks that the excessive increase of pressure value at the gastroduodenal junction may have been due to hyperperistalsis in the pylorus and delayed the gastric emptying rate.

It is well-known that either in the gastric tube for esophageal reconstruction after resection of esophageal cancer or in the proximal residual stomach after fundusectomy, the postoperative dysfunction of the gastric tube was seen in motility. Formerly, a pyloroplasty had been added to the gastric tube for improvement of the emptying rate and increase of ingestion. But it is recently controversial whether a pyloroplasty was necessary or not to the gastric tube.

As a matter of fact, it is suggested that there would be two factors causing prolongation of emptying in process of creating a gastric tube; the first, bilateral truncal vagotomy and the second, gastric transection. In this manometric experiment, the pressure value at the gastroduodenal junction in the gastric tube increased and such tendency was more remarkable in a small tube than in a large one as shown in MAKI and SHIRATORI's experiments. In the explanation of this phenomenon, they paid attention to occurrence of antiperistalsis due to gastric transection rather than vagotomy and stated that the antiperistaltic discharge produced higher intraluminal pressure than the normoperistaltic one. The author agrees with their opinion in the short-term experiment. But in the long-term experiment of electromyogram by the author, the antiperistaltic discharges distinctly decreased. In this regard, SHIMASAKI[31], SUGAWARA[33], and SUGANO[32] indicated that the antiperistalsis after gastric transection decreased gradually with the lapse of time. Here, it must be considered that, in the author's studies, the electromyogram was investigated not during ingestion but after a fast, and moreover, while the author performed the exclusion of gastric tube, they re-anastomosed at the transected portion. But it is suggested that, on the pressure value at the HPZ, the antiperistaltic discharges influenced decreasingly and

the gastric stasis due to bilateral truncal vagotomy did increasingly in a chronic state. Clinically, in patients who had undergone antethoracic or intrathoracic esophagogastrostomy, the intraluminal pressure at the gastroduodenal junction has been preserved and the motility of the gastric antrum seemed to be remained. The correlation was not clear between the pressure value and the gastric emptying time, but in the substituted gastric tubes in which the vagus nerves were not implanted because of cancerous invasion, no HPZ was verified and the antral motility should be probably desolated. Therefore it is presumed that the existence of HPZ at the gastroduodenal junction is necessary to some degrees for evacuation of gastric tube.

Taking into consideration these results and the fact that the pressure value at the HPZ increased in proportion with the size of gastric tube, it was reasonable that HEINEKE-MIKULICZ pyloroplasty, whose decompressive effect is high, and the implantation of the vagus nerves were added to the small gastric tube used for intrathoracic reconstruction and RAMSTEDT pyloromyotomy, whose effect is low, was added to the large gastric tube used for antethoracic reconstruction in the author's surgical clinic. UMEHARA and DAIDO[38] et al add a pyloroplasty to the gastric tube because the pylorus was spastic and its withdrawal pressure was elevated, and recommended the annular myotomy in the prepyloric region. On the other hand, TAKITA[34] reported that the motility of residual stomach recovered in time. And also, in clinical study[29], some patients had no complaint of passage disturbance and reflux esophagitis due to acid and pepsin even if a pyloroplasty had been not added. Moreover, INOGUCHI[12] described that the absorption disturbance of fat, diarrhea, dumping syndrome or exacerbation of bile reflux esophagitis was seen in patients with pyloroplasty. On the whole, many problems remained unsolved as to the addition of pyloroplasty.

Moreover, in gastroduodenal manometry, the difference was not recognized between the hepatic vagotomized tube group and the non-hepatic vagotomized tube group, but in electromyographic studies, it was supposed that the pyloric branch, ramifying from the hepatic vagal nerve, was concerned with the antiperistaltic discharge. This is an interesting problem and, in future, it will be studied in detail.

It has been accepted by many surgeons that a pyloroplasty had been necessary to truncal vagotomy and selective vagotomy. But as regards to its necessity for SPV, it is still controversial. AMDRUP[1], JENSEN[1], JOHNSTON[15] and NAGAO[24] believe that a pyloroplasty is unnecessary for SPV unless pyloric stenosis is present. On the other hand, HOLLE[8], TAKITA[35] and SAKAKIHARA[30] positively add a pyloroplasty to SPV In this study, the pressure value at the gastroduodenal junction was investigated in SPV with or without FINNEY pyloroplasty. Consequently, SPV group indicated the intraluminal pressure at the gastroduodenal junction more closely as the control group than SPV with pyloroplasty group. In other words, it is thought that the normal patterns of gastric motility have been kept in SPV without pyloroplasty. NAKAGAWA[25] considers that the gastric motility seems to be recovered because the AUERBACH's and MEISSNER's plexus have been preserved, even if transient dyskinesia has occurred after SPV Therefore he adds a pyloroplasty to SPV. NILSELL[27] reported as follows; in SPV without pyloroplasty, recurrence of peptic ulcer had occurred frequently, but in SPV with pyloroplasty, dumping

syndrome had occurred and been serious. At any rate, the problem whether pyloroplasty was necessary or not for SPV should be investigated not only in motility but also in secretion.

Conclusions

By gastroduodenal manometry with an open-tipped method, it was clarified that there was a HPZ at the gastroduodenal junction in dog with an amplitude of 23.7 ± 1.04 cm H_2O and a length of 0.5 to 1.5 cm.

(1) In physiological experiments using various kinds of gastrointestinal hormones and autonomic drugs, this HPZ seems to reflect both the peristaltic pressure of the gastric antrum and the size of the pyloric ring which is considered as a congenital narrow portion.

(2) After various kinds of pyloroplasties, the pressure values decreased respectively. Pylorectomy, HORSLEY, FINNEY and HEINEKE-MIKULICZ pyloroplasties tend to more effectively decrease pressure than the other methods.

(3) In the short-term experiment on bilateral truncal vagotomy, the pressure value decreased according to atony of the stomach. But gastric stasis advanced gradually and two weeks after the operation, the pylorospasm seemed to be produced secondarily.

(4) After SPV, normal patterns of gastric motility have been kept in the gastroduodenal junction and it seemed to be not necessary to add a pyloroplasty to SPV.

(5) After creating a gastric tube for esophageal reconstruction, the pressure value at the HPZ increased. This phenomenon seemed to be referred to gastric transection and bilateral truncal vagotomy, but with the lapse of time, it was suggested that vagotomy influenced more remarkably rather than transection. Moreover, the pressure value increased in proportion with the size of gastric tube. Therefore, it is reasonable that HEINEKE-MIKULICZ pyloroplasty and the implantation of the vagus nerves are added to the small tube used for intrathoracic reconstruction, and RAMSTEDT pyloromyotomy is added to the large tube used for antethoracic reconstruction in the author's surgical clinic.

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和文抄録

胃十二指腸接合部高圧帯からみた上部消化管手術と術後胃運動機能

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胸部食道癌切除後やKirschner-中山式胃管作成後には胃管の運動機能が障害され，その内容排出が遅延することが知られている．その対策として再建用胃管には通常幽門形成術が追加されるが，この要否にはなお問題点が残されている．これらの点を解明するとともに著者らが胸腔内食道胃吻合の際に行っている迷走神経胃管壁内埋込み術の効果に関しても検討を加えた．一方，十二指腸潰瘍に対する選近迷切における幽門形成術追加の要否についても議論が分かれているが，この点についても検討を行った．

1) open-tip 法を用いた内圧測定によって，絶食ネンブタール麻酔下のイヌの胃十二指腸接合部には長さ0.5～1.5 cm，頂値 23.7±1.04 cm H_2O の高圧帯を認めた．各種消化管ホルモンあるいは自律神経作動薬を用いた生理学的検討によって，この高圧帯は胃幽門洞部内圧および先天的狭窄部である幽門輪の大きさを反映しているものと思われた．

2) 各種幽門形成術によって，高圧帯圧値は下降した．幽門筋輪切除術，Horsley, Finney, Heineke-Mikulicz 型らの幽門形成術群は，Ramstedt, Holle, Judd, Moschel 型らの幽門形成術群よりも優れた減圧効果を示した．

3) 両側幹性迷切直後には，高圧帯圧値は胃壁の atony によって下降したが，次第に胃内容が停滞するため，迷切後2週には二次的に幽門痙攣を来たし，高圧帯圧値は上昇することが認められた．

4) 選近迷切では，正常な胃十二指腸接合部の運動パターンが保持されていた．

5) 食道再建用胃管作成後には高圧帯圧値は上昇した．これは胃横切および幹性迷切に起因するが，胃筋電図検査によって術後時が経つにつれて迷切の影響が強くなるものと推測された．また1/2胃管では2/3胃管に比べて高圧帯圧値は上昇する傾向を示した．

6) 臨床的検討によって，胸腔内食道胃吻合の際再建用胃管への迷走神経埋込み術を併施した症例では，非埋込み例に比べて胃十二指腸接合部にある程度の内圧が存在することが証明された．^{99m}Tc sulfur colloid 混入食摂取後の gastrogram でも胃管よりの内容排出は速やかであった．

以上の成績より，食道再建用胃管には幽門形成術の追加が必要であり，さらに迷走神経胃管壁内埋込みによって十分なドレナージ効果が得られることが判明した．一方，十二指腸潰瘍に対する選近迷切には幽門狭窄のない限り幽門形成術の追加は不要と思われた．